NATIONAL INSTITUTES OF HEALTH

FUME HOOD CONTAINMENT TESTING

By:

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A. GENERAL:

Test identified below was created by Farhad Memarzadeh of the National Institutes of Health in 1997 and further revised by Memarzadeh and Brightbill in 1999. The test shall be performed during static and dynamic conditions. Testing shall be conducted as outlined below for 50% of the hoods provided in the project. Tests shall be characterized and referred to in two basic categories "Static" and "Dynamic". While elements of both static and dynamic testing exist in both test categories, these names are generally used for reference.

B. STATIC TESTING:

Testing shall be conducted in accordance with **ASHRAE 110 - Method of Testing Performance of Laboratory Fume Hoods** with the following modifications.

This is primarily a test of the hood and laboratory configuration.

1. Hoods will be tested with simulated apparatus. This apparatus will consist of: two each 3.8 L round paint cans, one 300mm by 300mm by 300mm cardboard box, three each 150mm by 150mm by 300mm cardboard boxes. These items will be positioned from 150mm to 250mm behind the sash, randomly distributed, and supported off the work surface by 50mm by 50mm blocks.
2. The test gas will have a 6 LPM flow rate.
3. The test will be conducted at the center position for the manikin only.
4. Each test duration will be 5 minutes.
5. Acceptable test results will be 0.05 **PPM** or better. .
6. At the conclusion of each 5-minute test there will be three rapid walk-by at 300mm behind the manikin. Each walk-by will be spaced 30 seconds apart. If there is a rise in test gas concentration, it cannot exceed **0.10 ppm** and must return to **0.05 ppm** within 15 seconds.
7. There will be a minimum of three and a maximum of five people in the test room during the test procedure.
8. Representatives of the NIH will witness the tests.

C. DYNAMIC TESTING:

These tests primarily test the dynamic performance of the variable air volume (VAV) fume hood control system. This group of tests measures hood performance parameters through various dynamic "events". Events shall include four sash movements up and down across differing ranges: 25% - 100% and 50% - 100%, sash movements of other hoods on the exhaust duct, walk-bys in front of the hood, and opening and closing the laboratory door commensurate with a person entering and exiting the room.

1. **Hood parameters to be determined for each event are defined as follows (refer to the figure below for a graphical representation of some parameters):**

   a) **Measured Face Velocity** (FVm expressed in m/s): Face velocity measured in the plane of the sash. Samples shall be recorded at no less than 10 Hz. Sensing methodology shall have an internal time coefficient of no more than 20 ms. This shall basically be a point sensor located in the middle of the face opening when the sash is at the lowest position during the tested event. No less than three point sensors shall be used. Averages shall be calculated for any point in time to assess overall measured face velocity, however individual sensor samples shall be used in calculating TI.

   b) **Total Exhaust Air Flow** (TEFexpressed in L/s): Total exhaust flow measured in the main exhaust duct leaving the hood. This parameter shall be recorded at no less that 10 Hz. The sensing methodology used for the recorded data shall represent the total airflow through the full range of flows and be validated by independent multi-point measurement. If the fume hood control system uses a flow-sensing element, that element may be used assuming it can be calibrated across the full range of flow. Sensing elements must have an internal time coefficient of no more than 20 ms.

   c) **Variable Face Area** (FAv expressed in meters): Face Area of the hood that varies as the sash is moved within specified limits.

   d) **Fixed Face Area** (FAf expressed in meters): Face area of the hood with sash at minimum position (minimum position should correlate with the minimum bypass flow through the hood)

   e) **Hood Airflow Leakage** (HAL expressed in L/s): The difference in airflow between the measured airflow through the face (at minimum position) and the total airflow measured in the exhaust duct.

   f) **Calculated Face Velocity** (FVc): Face velocity determined from the following equation: ((TEF-HAL)*1000)/(FAv + FAf)

g) **Steady State Face Velocity** (SSFV): The average of all sampled face velocities for a 5 second period. Two SSFVs will be determined for both measured face velocity and calculated face velocity; one before the event (SSFVb) and one after (SSFVa). The SSFVa will start two seconds after the end of TSS. The second suffix of m for measured and c for calculated shall be used to indicated the type of assessment

h) **Face Velocity Baseline** (FVBL): The average of SSFVa and SSFVbh)

i) **Control Linearity** (CL expressed in %): Abs(SSFVa-SSFVb)/(FVBL)*100

j) **Time to Steady State** (TSS_{10} and TSS_5 expressed in seconds): The elapsed time from the initial sash movement until the FVc reaches and stays within \\" 10% or \\" 5% of FVBL (as indicated by the subscript)

k) **Face Velocity Overshoot/Maximum Deviation**- (FVO expressed in %): Calculated using the Calculated Face Velocity sample furthest from the FVBL (FVf) throughout the test per the following equation:
(Abs(FVf-FVBL)/FVBL)*100.

Samples include initial face velocity deviation immediately following the sash movement as the controls initially respond to the movement of the sash.

l) **Response Time Constant** (RTC expressed in seconds): Elapsed time between initial movement of the sash and the initial subsequent movement of the exhaust valve.

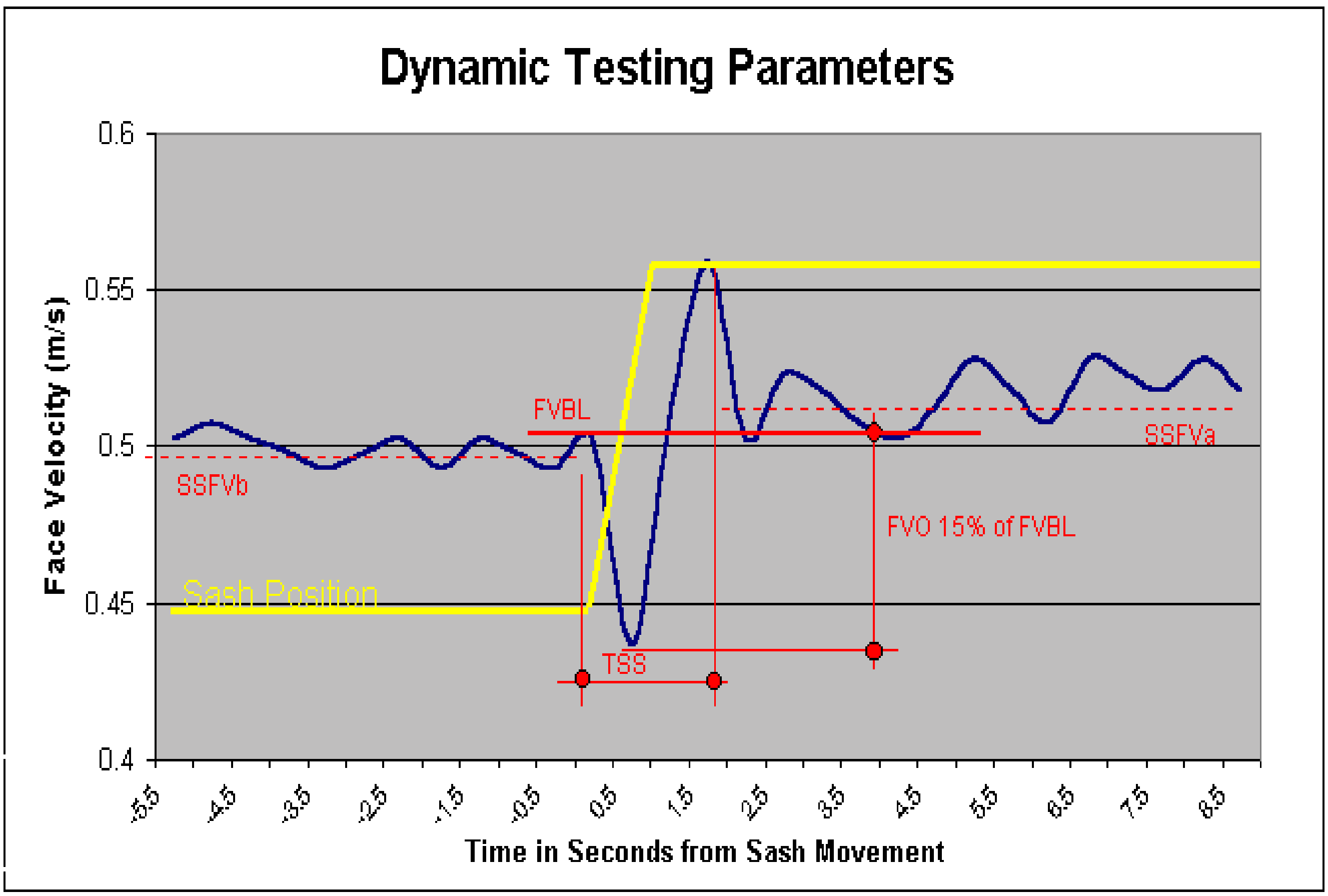
m) **Steady State Deviation** (SSD expressed in %): Face velocity variation from SSFVa or SSFVb as applicable. Calculated using the furthest sample from the applicable SSFV (FVf) using the following equation:
(Abs(FVf-SSFVx)/SSFVx)*100

n) **Controllability** (expressed in mV/mm): Describes controller response to changing sash position, i.e.: Controllers response signal change per unit distance of sash movement

o) **Sash Position** (SP expressed in mm): For vertical sashes - Vertical distance from the sill of the hood to the bottom of the sash. The minimum sash position shall correlate to the position of the sash when the minimum flow through the hood is all through the face. Maximum sash position shall be defined as a distance of 550-650mm. This parameter shall be recorded at no less than 10 Hz

p) **Controller Output** (CO expressed in Volts): Control output to the controlling exhaust air valve. This parameter shall be measured and recorded at no less than 10 Hz.

q) **Turbulence Intensity** (TI expressed in m/s): Calculated root mean square calculated for each of the steady state conditions preceding and following each event. This shall be correlated to a "Box Leakage Factor" of the installation using the ***Methodology for Optimization of Laboratory Fume Hood Containment*"** (MOLHC) by NIH Office of the Director, Farhad Memarzadeh principal investigator. While this value does not have a pass/fail requirement, it is the fundamental indicator of containment and therefore shall be clearly reported.



2. Parameter Performance Requirements:

a) **Face Velocity Baseline** (FVBL): .51 m/s \\" .05m/s

b) **Control Linearity** (Cl expressed in %): < 2%

c) **Time to Steady State$_{10}$** (TSS_{10} expressed in seconds): < 2 Seconds

d) **Time to Steady State$_5$** (TSS_5 expressed in seconds): < 3 Seconds

e) **Face Velocity Overshoot/Maximum Deviation**: < 15% which means at no point throughout the test shall a sample be recorded <0.43 m/s or > 0.59 m/s

f) **Response Time Constant** (RTC expressed in seconds): < 0.5 Second

g) **Steady State Deviation** (SSD expressed in %): < 5% assessed using calculated face velocities

h) **Controllability** (expressed in mV/mm): > 12 mV/25.4mm

3. Alternate Parameter Performance Requirements: The following performance parameters are alternate requirements that can be used in assessing acceptable dynamic responses.

a) **Face Velocity Baseline (FVBL)**: .51 m/s \\" .05m/s

b) **Calculated Face Velocity (FVc):** All samples >0.255 m/s and <.89 m/s meaning that at no time during the event shall the calculated face velocity go outside that range. Any sample recorded beyond that range will result in assessing the response as unacceptable.

c) **Control Linearity** (Cl expressed in %): < 2%

d) **Time to Steady State$_{10}$** (TSS_{10} expressed in seconds): < 1.6 Seconds

e) **Time to Steady State$_5$** (TSS_5 expressed in seconds): < 2 Seconds

f) **Response Time Constant** (RTC expressed in seconds): < 0.5 Seconds

g) **Steady State Deviation** (SSD expressed in %): < 5% assessed using calculated face velocities

h) **Controllability** (expressed in mV/mm): > 12 mV/25.4mm

D. TEST EXECUTION:

Testing agency shall be equipped to execute the testing and assess all performance parameters on site the day of the test. Data acquisition of required parameters shall be simultaneous.

E. TEST DOCUMENTATION:

All testing, calculated, and recorded parameters shall be presented in a report that shows the recorded parameters graphically and tabulates and summarizes all the results. Performance of the hood, the hood controls, and the laboratory in general shall be described and summarized.

FUME HOOD CONTROL TESTING (OFF SITE MOCK UP)

A. The manufacturer of the proposed fume hood control system shall mock up a fume hood installation and demonstrate the performance their system to validate that they can meet the requirements specified herein. The hood to be tested shall be set up in a test room of sufficient size so that a minimum of 5 feet of clear space is available in front of and on both sides of the hood for viewing of performance tests. The off site test shall include all parameters under the control of the control system (FVBL, TSS, CL, RTC, SSD, and Controllability). It is not necessary to mock up the installation and assess TI. Events to be tested off site include all specified sash movements on the hood being tested. Walkbys and door opening affects are not required for the off site test.

B. The testing shall be accomplished by an independent testing agency approved by the Procurement Officer (NIH). Reports shall be provided with the laboratory control submittals and no approval will be given for the fume hood control system until documentation of successful demonstration of the performance requirements are submitted.

TEST ROOMS

A TEST ROOM

The hood to be tested shall be set up in a test room of sufficient size so that a minimum of 5 feet of clear space is available in front of and on both sides of the hood for viewing of performance tests.

B EXHAUST SYSTEM

A hood exhaust system, properly calibrated so that known exhaust air volumes can be easily attained, shall be provided. The exhaust capacity shall be sufficient to exhaust the hood with a face velocity of 100 fpm.

VELOCITY MEASUREMENTS

A FACE VELOCITY

Using a calibrated hot wire anemometer, determine the hood face velocity profile by the methods described in SAMA LF10-1980. Face velocity measurements shall meet an air velocity profile of 100 fpm plus or minus 10 fpm with the sash fully open.

STATIC PRESSURE READINGS

A HOOD STATIC PRESSURE

Take traverse readings to measure exhaust rate and measure the hood static pressure two straight-line duct diameters downstream from the point of connection between the hood and the exhaust line. The readings shall be taken with a face velocity of 100 plus or minus 10 fpm at the full open sash position. The laboratory fume hood shall have a maximum hood static pressure of 0.5 "w.g. Include all readings and a schematic of the test set-up with the test data results.

Reference:

Memarzadeh, F., 1996, *Methodology for Optimization of Laboratory Hood Containment,* National Institutes of Health.

T.M. Rabiah, R.P. Garrison, R.K. Sachdev, 1989, *Comparison of Variable Volume Fume Hood Controller,* ASHRAE Transaction 1989. V.95,P1.2.

Saunders, T., 1993, *Laboratory Fume Hoods, A User Manual,* John Willy & Sons, Inc.